Karlsruhe Institute of Technology

Helmholtz Russian Joint Research Group

Measurements of Gamma Rays and Charged Cosmic Rays in the Tunka-Valley in Siberia by Innovative New Technologies

The Tunka Radio Extension (Tunka-Rex): A new radio detector for cosmic ray air showers

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INSTITUT FÜR KERNPHYSIK

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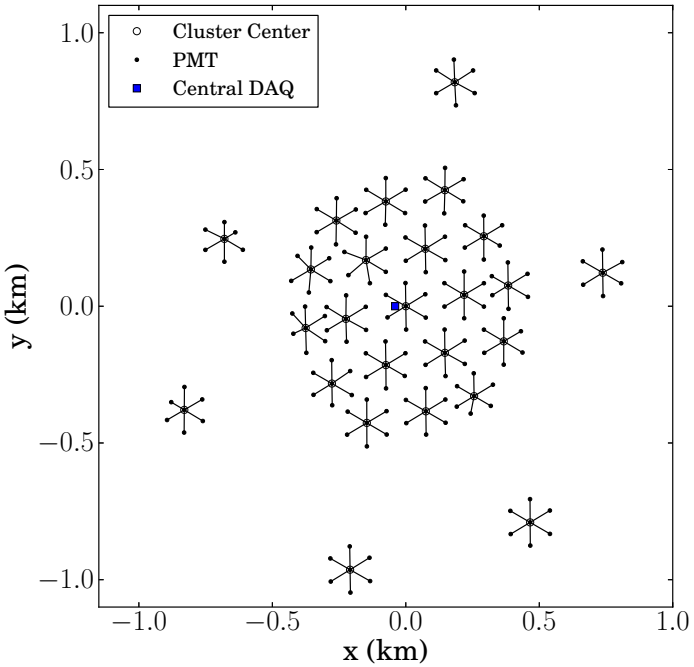
Tunka-133

- 1 km^2 air-Cherenkov detector
- 133 upward looking PMTs
- Energy 10^{16}-10^{18} eV

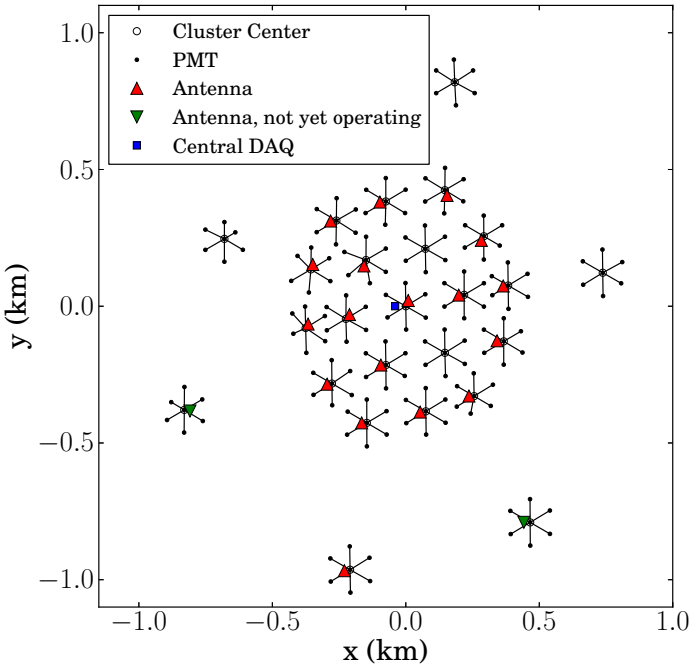


Resolution for cosmic ray air showers:

- Energy 15%
- X_{max} 28 g/cm^2

Tunka-Rex

- Radio extension to air-Cherenkov array
- Antennas connected to PMT clusters
- Externally triggered by PMTs
- Started Oct. 2012



Motivation

Advantages at the site:

- Existing DAQ
- Trigger and information from air-Cherenkov detector
- Radio quiet, rural location

Main goals:

- Cross calibration air-Cherenkov + radio hybrid measurements
- Determine radio energy precision
- Determine radio X_{max} precision

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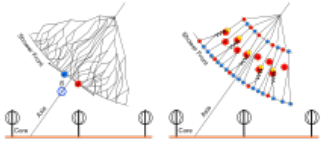
Radio emission from air showers

- MHz radio pulse from the shower front
- Two important emission mechanisms:

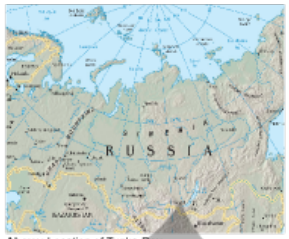
Geomagnetic effect [1]
-deflection of e^+e^-
-time-varying transverse currents

Askaryan effect [2]
-time-varying net charge
-typical contribution 10%



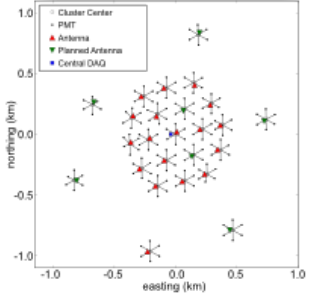
Tunka-Rex

- Radio extension of Tunka-133 [3] (1 km² air-Cherenkov detector for cosmic rays in Siberia)
- Started 2012 with 20 antenna stations, planned upgrade to 25 stations
- Hybrid measurements of air showers with 10^{17}-10^{18} eV primary energy
- Cross-calibration of Radio + air-Cherenkov detector



Above: Location of Tunka-Rex.
Below: Map of the Tunka-133 clusters and Tunka-Rex with one antenna next to each cluster center.

A Tunka-Rex antenna station. It has two SALLA type antennas, aligned along the NE-SW and NW-SE axis.

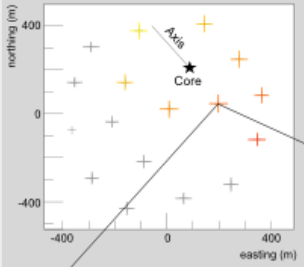


Technical Data

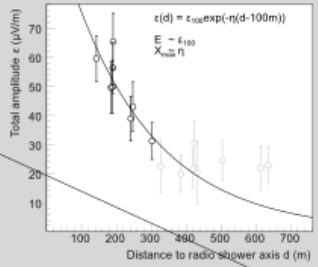
- Trigger and DAQ: by Tunka-133 main detector
- Antenna spacing: 200 m
- Antenna type: SALLA [4] (2 channels)
- Alignment: 45° and 135°
- Frequency band: 30-80 MHz, sampled at 200 MHz

Example event

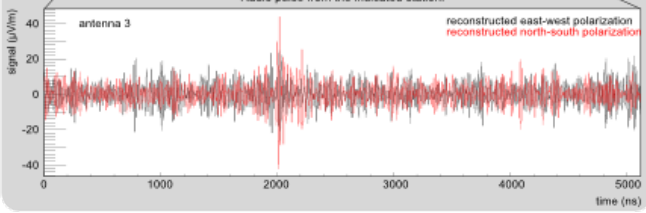
Footprint of a shower measured in 2013. The color code indicates the arrival time of the radio pulse.



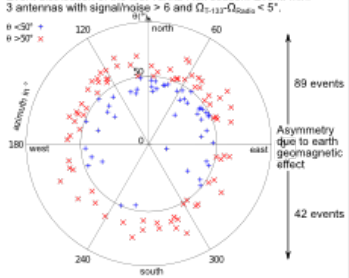
Lateral distribution of reconstructed radio amplitudes for the shown event.



Radio pulse from the indicated station.



Event distribution of the first Tunka-Rex season. Event: min. 3 antennas with signal/noise > 6 and Ω_{T-133}-Ω_{Radio} < 5°.



Goals of Tunka-Rex

- Determine the **achievable precision** with the radio technique (energy and composition)
- Is a radio detector a **feasible and economic** alternative for large-scale observatories for air showers?
- **Increase** the Tunka **statistics** at the highest energies

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References

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[4] O.Krömer, *et al.* (LOPES Collaboration), Proc. 31st ICRC, Lodz, Poland, 2009.

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